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ABSTRACT

Background information on the shortage of teachers in mathematics and science is first summarized, with discussion of reasons why fewer persons are entering teaching and many experienced teachers are leaving. Then the Midcareer Mathematics and Science Program is described. It is designed to provide mid- to late-career professionals who already possess quantitative backgrounds with the training they need to become secondary school mathematics and science teachers. With six students in 1983 and 20 in 1984, it reaches those for whom the economic constraints of teaching are of less concern, status has already been attained in another field, and the change of pace and environment are welcomed. Conducted during the academic year with optional summer workshops, the eight courses in the program are divided among educational theory, methods of teaching mathematics and science, classroom practice, and electives. Consideration of developmental psychology and of schools as organizations are included, and participants work directly with practicing classroom teachers in a variety of high school settings. The program's objectives and its advantages are both discussed. (MNS)

THE MIDCAREER MATH AND SCIENCE TEACHER TRAINING PROGRAM AT HARVARD UNIVERSITY

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I. Introduction

The Trickle and Flood of Math/Science Teachers

The condition of American mathematics and science education at the secondary level has deteriorated significantly over the past twenty years. Both the numbers of students studying math and science and their achievement levels as measured by SAT's and the National Assessment of Educational Progress have declined steadily since the early sixties.[1] This disturbing situation comes at a time when industry's need for qualified workers with math and science backgrounds -- from Ph.D-level senior scientists to high school educated technicians -- is on the rise. Moreover, even those students who go on to non-technical careers often lack a minimum level of math and science competency required for non-quantitative jobs and daily living.

The federal commissions, state legislative task forces, private foundations and individual scholars investigating the sources of these downward trends all stress the critical importance of the classroom teacher in the delivery of a quality education. Findings generated by these studies indicate that the current math/science education crisis is due, in significant part, to:

1) A critical shortage of entry-level teachers certified in physics, math and chemistry; and

2) Significant attrition among experienced math and science teachers who are leaving education for higher paying jobs in industry.

The trickle of qualified secondary school math and science teachers entering and the flood of those leaving the profession are becoming increasingly acute. In 1980, America's institutes of higher education produced 78% fewer math teachers and 64% fewer science teachers than they had in 1971. In 1981, 42 states (out of 46 responding to a privately conducted survey) reported either a "critical shortage" or a "shortage" of mathematics and physics teachers.[2]

The decline in entry-level math and science teachers is the result of economic, social and demographic forces. Young, capable college graduates with scientific ability are finding that their aptitudes and training are worth far more earning power in industry than in education. Starting salaries in the computer or banking industries for technically trained individuals often rank between twenty-five and thirty thousand dollars, while in 1982, the mean starting salary for new teachers with Master's degrees in Massachusetts was $13,762.[3] Not only are starting salaries much lower, but opportunities to reach a high salary level after lengthy service are non-existent in education. Thus, for example, the average maximum scheduled

salary of public school teachers in Massachusetts in 1981 was $24,000.

The exodus of experienced teachers to non-education fields is also economically and socially based. In 1981, almost five times more science and mathematics teachers left their school systems to take non-teaching jobs than left due to retirement.[4] And this trend promises to continue: a recent survey of mathematics and physics teachers in the Boston area indicated that within the next two years, six out of ten math teachers plan to leave teaching, while 13 out of 19 physics teachers hope to find other non-teaching positions.[5] In addition to the obvious economic advantages of such a career change, these professionals are making the move to industry because they believe that society does not value their contributions. Their beliefs are reinforced by low salaries and the general societal attitude that teachers are involved in little more than sophisticated childcare.

Negative economic and social conditions are exacerbated by demographic changes that will heavily influence the future production of math and science teachers; over the next dozen years there will be more than a 25% drop in the number of 18-25 year olds. Neither the pay differentials suggested by some to bridge the economic gap, nor the bills pending in Congress to forgive undergraduate student loans for the study of scientific education[6] address the fact that the traditional labor pool for new teachers -- those in their early twenties -- will decrease significantly over the next decade. Moreover, women, who historically have entered the teaching profession in great numbers, now are finding additional career opportunities in other fields.

In sum, the higher salaries and greater prestige of careers in private industry are drawing both new and existing teachers away from the teaching profession. As a result, the nation's greatest resource and hope for the future, our children, are being denied the level of mathematics and technology education they need to remain on a par with the students of other countries and cultures. Moreover, without adequate exposure to the kinds of independent thought, analytic judgment and problem-solving skills encouraged by superior math and science education, our children will graduate from secondary school as technical illiterates -- entering a society increasingly driven by science and technology. To avert such a fate, we must find alternative sources of qualified and dedicated math and science teachers to participate in the education of our youth.

An Innovative Solution: The Midcareer Math and Science Program

To address the increasingly critical shortage of math and science teachers, the Harvard Graduate School of Education (HGSE) has launched an innovative Midcareer Math and Science Program. The MCMS Program is designed to provide mid to late-career professionals who already possess quantitative backgrounds in high

technology, scientific research and financial services with the training they need to become secondary math and science classroom teachers. The Program, which awards either a Master's degree or a Certificate of Advanced Study, is conducted during the academic year with optional summer study workshops, and meets the Massachusetts certification requirements for secondary school teachers.7/

The MCMS Program has four objectives:

- To improve the condition of math and science education for children at the precollegiate level by crafting an innovative response to the shortage of qualified new teachers and the attrition of experienced professionals;
- To demonstrate that a previously underutilized and large labor pool for education -- mid/late career professionals -- can and will make a significant contribution to the education of our nation's youth;
- To infuse school settings and curricula with knowledge conveyed by mid-career professionals of real world applications of math and science; and
- To offer an innovative model for other educational institutions across the country to address the condition of secondary mathematics and science education at the local level.

We believe that midcareer professionals are a particularly appropriate source of new teachers. Many potential participants in the fifty to sixty year old bracket are eligible for early retirement or voluntary severance plans. Depending on the industry and the employee's status, good pension plans are also available to them, frequently guaranteeing up to 50% of previous income levels. For most individuals in this age bracket, the two most significant financial expenses of their careers -- mortgage payments and college tuitions --are often well behind them. With potential tax advantages and changing financial requirements, a new career in teaching may not be as economically constraining for a midcareer professional as it is for a young teacher.

The social argument that teaching is not a status-conferring career also bears less influence on midcareer professionals because the midcareer professional has already established his /her reputation in another field. Recent research on career development, indicates that many individuals in this age bracket have economically -- and psychologically -- "plateaued" in the corporate world and would welcome an opportunity for new challenges.8/An advantage to teaching as a second career is that it offers many professionals a change of pace and a new employment environment. Teaching also offers those who feel a social commitment to the young of our society -- and to the type of education which, in part, enabled them to succeed in their first careers -- with an opportunity to serve.

The demographic factors that will contribute to the trickle of young people entering teaching are also more favorable for the midcareer group. While the number of 19-24 year olds will plummet in the next decade, the group of 49-54 year olds will increase significantly. This factor, coupled with the increasing interest of professionals to work beyond the age of 62 or 65, makes the potential contribution of this midcareer group extremely large.

Enthusiasm for the MCMS Program has been high since its inception one year ago; many mid-career professionals, in fact, are interested in persuing a second career as a secondary school teacher. During the MCMS' first year of operation, its Program Director received over 400 inquiries about Program activities and requirements. Continuing press coverage not only in general interest publications (e.g., newspapers and education-related magazines) but in professional journals (Machine Design, Engineering Times, etc.) have continued to generate requests and applications from potential students all over the country. For example, a recent article in "Afterburner," a magazine for retired Air Force officers, generated 75 requests for information in two weeks.

The MCMS Program began in September 1983, with an initial class of six students. By the fall of 1984, the size of the Program will expand to twenty. The men and women participating in the Program's first two years have diverse backgrounds and experiences: the first year's student body consisted of a retired army colonel with an advanced degree in nuclear engineering, a photographic scientist most recently involved in eye research, a Ph.D. chemical engineer, two electrical engineers with experience in high technology and software design, and a housewife with a background in biology. Next year's class will include a retired rear admiral, a chief meterologist from the United States Weather Service, a microbiologist, a biochemist, two physicists, civil and electrical engineers, and a missile systems expert.

MCMS Program participants, who range in age from their late thirties to early sixties, bring outstanding academic qualifications to their new careers. Nearly all have Master's Degrees or Doctorates in the fields in which they want to teach and over 15% have completed their studies as Phi Beta Kappas. Nearly all have scored above the 95th percentile of the Graduate Record Examination and their mean score on the Miller Analogies Test is 76. This latter statistic ranks the MCMS student considerably higher than the average graduate education school applicant whose average Miller Analogies score is 48.2.

The reasons these participants have given for wanting to become classroom teachers at mid-career are varied, but two common themes emerge: the desire to change the quality of their own lives and the wish to contribute to the education of young people. Take, for instance, Anthony Copas, a Ph. D chemical engineer who was among the Program's fi graduates. Copas

resigned his position with a private firm to become a high school science teacher because he was not satisfied with his current research position and wanted to pursue a long-standing interest in teaching. As Copas explained,

> I've acquired all this knowledge [while obtaining a Ph.D.] and I'm looking for an opportunity to pass it along. It's not that I don't feel good about engineering! But I think I'd feel better if I had a chance to influence some students. I want to do something more meaningful with my life.

Starting this fall, Mr. Copas will teach physics amd mathematics in a secondary school in Salt Lake City, Utah.

Similarly, Robert Bliss has enrolled in the MCMS Program to fulfill a life-long dream. Although he collects early retirement from his 25-year engineering career with a large manufacturing firm, he does not like the inactivity implied by retirement. Like Copas, he wants to use his experience in business and industry to enrich the lives of the young. He explains,

> Just observing my own children, I know that if their teacher had possessed a knowledge of how these things could be applied in industry, it might have taken them beyond the required two years of math.

The nine months of study provided by the MCMS Program include a total of eight courses divided among educational theory, methods of teaching math and science, classroom practice and electives. Building on the in-depth subject matter expertise and familiarity with real-world applications that Program participants already possess, the MCMS program provides them with the skills and credentials they need to teach in their subject areas as well as a more realistic perspective on the educational process. More specifically, the academic program includes:

- The study of teaching and learning from a developmental psychology perspective. Topics include what kinds of experiences affect a learner's construction of knowledge, and what is the teacher's role.

- The study of schools as organizations. Topics include the general climate of schools, the structure of work, bureaucratic expectations, key organizational features, and the developmental stages of a teacher's career.

- The study of the practice of teaching in specific subject areas. Topics here include familiarization with curricula and instructional techniques in physics, math biology, and chemistry.

The Program's participants also take a variety of elective courses at the Graduate School of Education and other schools of Harvard University. These courses range from Adolescent Psychology to the Philosophy of Science. In addition, nearly all of the Program's students participate in an examination of the psychological, pedagogical and social impacts of interactive technologies on thinking and learning in the classroom.

Beyond their work at Harvard, participants work directly with practicing classroom teachers in a variety of high school settings. The Program strongly emphasizes this field-based component and encourages the active participation of classroom teachers in the training of these new teachers. The ratio of HGSE personnel who supervise the practice teaching component of the Program to students is high and mentor teachers within participating school districts receive special training to enhance their contact with Program participants.

Although twenty students per year may seem to be a small number in the face of the critical shortages described above, the impact of the MCMS Program should not be underestimated. If we conservatively estimate that the twenty-six individuals graduating in the MCMS Program's first two years each teach 100 students per year, by the end of the fifth year of the Program, these individuals will have directly affected the education of 8400 secondary school students who might otherwise have been taught with less commitment, less enthusiasm, and less awareness of how math and science directly impact the quality of each student's daily life.

Moreover, one of the primary goals of the MCMS Program is to disseminate strategies for bringing mid-career professionals into the teaching profession. To this end, the Program has been designed to serve as a model for other institutions of higher education. Already inquiries from such potential Program adopters as the Universities of California at Berkeley, Western Michigan, Seattle, Rutgers, Lewis and Clark, Indiana, Bridgeport, Fordham and George Washington as well as twenty-five other institutions of higher learning and state legislatures in Texas, Oklahoma, Michigan and South Carolina have spread the Program's influence far beyond its initial group of graduates.

In sum, the Harvard Graduate School of Education's Midcareer Math and Science Program offers unique advantages to several constituencies:

- For our nation's children, this Program provides well-trained professionals to deliver math and science instruction. Such instruction, enthusiastically and knowledgeably delivered, will enable students to function better as individuals and contributing members of our society.

- For our nation's schools, the Program recognizes, develops and utilizes a new labor pool never seriously considered before. This model represents a powerful potential to address concerns of teacher quality and preparation in secondary education.

- For business and industry, the Program helps to produce better trained young people to enter the workforce. In addition, it offers the potential of greater flexibility and increased productivity within the corporation as a result of viable career alternatives for current employees.

- For other graduate schools of education, this Program stands as a model of a creative utilization of resources and personnel to address the status of pre-collegiate math and science education. The Program is designed to be replicated in other parts of the country with evaluation results widely shared.